

**Claims**

1. A method for treating a wastewater stream, consisting essentially of acts of:  
(a) adding, at a first position in the wastewater stream, a nitrate containing  
compound to the wastewater stream in an amount sufficient to reduce a concentration of at  
least one of atmospheric hydrogen sulfide and dissolved sulfide downstream of the first  
position to a desired concentration; and

(b) adding, at a second position in the wastewater stream, a compound consisting  
essentially of an alkaline material to the wastewater stream to reduce the amount of the  
nitrate containing compound added in act (a).

2. The method of claim 1, wherein the acts (a) and (b) are performed at the  
same position.

3. The method of claim 1, wherein acts (a) and (b) are performed  
simultaneously by adding a predetermined mixture of the nitrate containing compound and  
the compound consisting essentially of the alkaline material.

4. The method of claim 3, wherein the predetermined mixture includes  
sodium nitrate and sodium hydroxide.

5. The method of claim 1, wherein the compound consisting essentially of the  
alkaline material includes at least one of calcium hydroxide and sodium hydroxide.

6. The method of claim 1, wherein the nitrate containing compound includes  
calcium nitrate.

7. The method of claim 1, wherein the nitrate containing compound includes  
anthraquinone, and wherein the acts (a) and (b) are performed separately.

8. The method of claim 1, wherein the nitrate containing compound includes  
anthraquinone, and wherein the first position is spaced apart from the second position.

9. The method of claim 1, wherein the act (b) reduces the amount of the nitrate containing compound added in act (a) by at least 10%

10. The method of claim 1, wherein the act (b) reduces the amount of the  
5 nitrate containing compound added in act (a) by at least 20%.

11. The method of claim 1, wherein the act (b) reduces the amount of the nitrate containing compound added in act (a) by at least 30%

10 12. The method of claim 1, wherein the act (b) includes an act of adding the compound consisting essentially of the alkaline material to the wastewater stream in an amount sufficient to increase a pH of the wastewater stream downstream of the first position by approximately one unit of pH.

15 13. The method of claim 1, wherein the act (b) includes an act of adding the compound consisting essentially of the alkaline material to the wastewater stream in an amount sufficient to increase a pH of the wastewater stream downstream of the first position to between approximately 7.5 to 8.5 units of pH.

20 14. The method of claim 1, wherein the act (a) reduces the concentration of atmospheric hydrogen sulfide and dissolved sulfide downstream of the first position by at least 10%, and wherein the act (b) reduces the amount of nitrate containing compound added in act (a) by at least 10%.

25 15. In a wastewater treatment system that adds an amount of a nitrate containing compound to a wastewater stream at a first position in the wastewater stream to reduce a concentration of at least one of atmospheric hydrogen sulfide and dissolved sulfide downstream of the first position to a desired concentration, a method, consisting essentially of:

30 adding, at a second position in the wastewater stream, an amount of a compound consisting essentially of an alkaline material to the wastewater stream to reduce the amount of the nitrate containing compound used to reduce the concentration of the at least

one of the atmospheric hydrogen sulfide and the dissolved sulfide to the desired concentration.

16. The method of claim 15, wherein the act of adding includes an act of adding, at the second position in the wastewater stream, a sufficient amount of the compound consisting essentially of the alkaline material to the wastewater stream to reduce the amount of the nitrate containing compound used to reduce the concentration of the at least one of the atmospheric hydrogen sulfide and the dissolved sulfide to the desired concentration by at least 20 %.

17. The method of claim 15, wherein the act of adding includes an act of adding, at the second position in the wastewater stream, a sufficient amount of the compound consisting essentially of the alkaline material to the wastewater stream to reduce the amount of the nitrate containing compound used to reduce the concentration of the at least one of the atmospheric hydrogen sulfide and the dissolved sulfide to the desired concentration by at least 30 %.

18. The method of claim 17, wherein the sufficient amount of the compound consisting essentially of the alkaline material raises a pH of the wastewater stream downstream of the first position by approximately one unit of pH.

19. The method of claim 17, wherein the sufficient amount of the compound consisting essentially of the alkaline material raises a pH of the wastewater stream downstream of the first position to between approximately 7.5 and 8.5 units of pH.

20. The method of claim 15, wherein the amount of the compound added at the second position is sufficient to raise a pH of the wastewater stream downstream of the first position by approximately one unit of pH.

21. The method of claim 15, wherein the amount of the compound added at the second position is sufficient to raise a pH of the wastewater stream downstream of the first position to between approximately 7.5 and 8.5 units of pH.

22. A method of treating a wastewater stream, comprising acts of:

- (a) adding a nitrate containing compound at a first position in the wastewater stream;
- (b) adding an alkaline material at a second position in the wastewater stream;
- 5 (c) sensing a level of at least one of atmospheric hydrogen sulfide, dissolved sulfide, and residual nitrate in the wastewater stream downstream of the first and second positions; and
- (d) adjusting an amount of at least one of the nitrate containing compound and the alkaline material added to the wastewater stream in response to the act of sensing.

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23. The method of claim 22, wherein the act (d) is performed by a computer.

24. The method of claim 22, wherein the act (b) includes an act of adding the alkaline material in an amount sufficient to raise a pH of the wastewater stream  
15 downstream of the first and second positions by approximately one unit of pH.

25. The method of claim 22, wherein the act (b) includes an act of adding the alkaline material in an amount sufficient to raise a pH of the wastewater stream downstream of the first and second positions to between approximately 7.5 and 8.5 units  
20 of pH.

26. The method of claim 22, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide and the level of dissolved sulfide in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an  
25 act of increasing an amount of the nitrate containing compound added in act (a) when the level of at least one of atmospheric hydrogen sulfide and dissolved sulfide sensed in act (c) is greater than a desired level.

27. The method of claim 22, wherein the act (c) includes an act of sensing the  
30 level of atmospheric hydrogen sulfide and the level of dissolved sulfide in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of increasing an amount of the nitrate containing compound added in act (a) when the

level of atmospheric hydrogen sulfide and the level of dissolved sulfide sensed in act (c) are greater than a desired level.

28. The method of claim 22, wherein the act (c) includes an act of sensing the  
5 level of atmospheric hydrogen sulfide and the level of dissolved sulfide in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of increasing an amount of the alkaline material added in act (b) when the level of at least one of atmospheric hydrogen sulfide and dissolved sulfide sensed in act (c) is greater than a desired level.

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29. The method of claim 22, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide and the level of dissolved sulfide in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of increasing an amount of the alkaline material added in act (b) when the level of  
15 atmospheric hydrogen sulfide and the level of dissolved sulfide sensed in act (c) are greater than a desired level.

30. The method of claim 22, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide and the level of dissolved sulfide in the wastewater  
20 stream downstream of the first and second positions, and wherein the act (d) includes acts of increasing an amount of the nitrate containing compound added in act (a) and increasing an amount of the alkaline material added in act (b) when the level of atmospheric hydrogen sulfide and the level of dissolved sulfide sensed in act (c) are greater than a desired level.

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31. The method of claim 22, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide and the level of dissolved sulfide in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of decreasing an amount of the nitrate containing compound added in act (a) when the  
30 level of at least one of atmospheric hydrogen sulfide and dissolved sulfide sensed in act (c) is less than a desired level.

32. The method of claim 22, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide and the level of dissolved sulfide in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of decreasing an amount of the nitrate containing compound added in act (a) when the  
5 level of atmospheric hydrogen sulfide and the level dissolved sulfide sensed in act (c) are less than a desired level.

33. The method of claim 22, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide and the level of dissolved sulfide in the wastewater  
10 stream downstream of the first and second positions, and wherein the act (d) includes an act of decreasing an amount of the alkaline material added in act (b) when the level of at least one of atmospheric hydrogen sulfide and dissolved sulfide sensed in act (c) is less than a desired level.

34. The method of claim 22, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide and the level of dissolved sulfide in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of decreasing an amount of the alkaline material added in act (b) when the level of  
15 atmospheric hydrogen sulfide and the level of dissolved sulfide sensed in act (c) are less  
20 than a desired level.

35. The method of claim 22, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide and the level of dissolved sulfide in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes acts  
25 of decreasing an amount of the nitrate containing compound added in act (a) and decreasing an amount of the alkaline material added in act (b) when the level of atmospheric hydrogen sulfide and the level of dissolved sulfide sensed in act (c) are less than a desired level.

36. The method of claim 22, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide, the level of dissolved sulfide, and the level of residual nitrate in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of decreasing an amount of the nitrate containing  
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compound added in act (a) when the level of atmospheric hydrogen sulfide and the level of dissolved sulfide sensed in act (c) are less than a desired level and an average level of residual nitrate sensed in act (c) is approximately 1-2 mg/L or greater.

5           37.     The method of claim 36, further comprising acts of:  
              (e) sensing a pH of the wastewater stream at or prior to the second position; and  
              (f) sensing a pH of the wastewater stream downstream of the first and second  
positions.

10           38.     The method of claim 37, wherein the act (d) further includes an act of  
decreasing an amount of the alkaline material added in act (b) when the act (f) indicates  
that the pH of the wastewater downstream of the first and second positions is at least one  
unit of pH higher than the pH of the wastewater stream sensed in act (e).

15           39.     The method of claim 22, wherein the act (c) includes an act of sensing the  
level of atmospheric hydrogen sulfide, the level of dissolved sulfide, and the level of  
residual nitrate in the wastewater stream downstream of the first and second positions, and  
wherein the act (d) includes an act of decreasing an amount of the alkaline material added  
in act (b) when the level of atmospheric hydrogen sulfide sensed in act (c) is less than a  
20   first desired level, the level of dissolved sulfide sensed in act (c) is greater than a second  
desired level, and an average level of residual nitrate sensed in act (c) is approximately 1-2  
mg/L or greater.

              40.     The method of claim 22, wherein the act (c) includes an act of sensing the  
25   level of atmospheric hydrogen sulfide, the level of dissolved sulfide, and the level of  
residual nitrate in the wastewater stream downstream of the first and second positions, and  
wherein the act (d) includes an act of increasing an amount of the alkaline material added  
in act (b) when the level of atmospheric hydrogen sulfide sensed in act (c) is greater than a  
first desired level, the level of dissolved sulfide sensed in act (c) is less than a second  
30   desired level, and an average level of residual nitrate sensed in act (c) is approximately 1-2  
mg/L or greater.

              41.     The method of claim 22, further comprising acts of:

(e) sensing a pH of the wastewater stream at or prior to the second position; and  
(f) sensing a pH of the wastewater stream downstream of the first and second positions.

5           42.     The method of claim 41, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide and the level of dissolved sulfide in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of decreasing an amount of the alkaline material added in act (b) when the level of atmospheric hydrogen sulfide and the level of dissolved sulfide sensed in act (c) are less  
10     than a desired level, and the act (f) indicates that the pH of the wastewater downstream of the first and second positions is at least one unit of pH higher than the pH of the wastewater stream sensed in act (e).

15           43.     The method of claim 41, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide, the level of dissolved sulfide, and the level of residual nitrate in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of decreasing an amount of the alkaline material added in act (b) when the level of atmospheric hydrogen sulfide and the level of dissolved sulfide sensed in act (c) are less than a desired level, the level of residual nitrate sensed in act (c)  
20     is negligible, and the act (f) indicates that the pH of the wastewater downstream of the first and second positions is at least one unit of pH higher than the pH of the wastewater stream sensed in act (e).

25           44.     The method of claim 22, wherein the acts (a) and (b) are performed at a same position in the wastewater stream.

          45.     A wastewater treatment system, comprising:  
a nitrate source in fluid communication with the wastewater;  
an alkaline material source in fluid communication with the wastewater;  
30     at least one sensor, disposed in the wastewater downstream of the nitrate source and the alkaline material source, to measure a level of at least one of atmospheric hydrogen sulfide and dissolved sulfide downstream of the nitrate source and the alkaline material source; and

means, responsive to the measured level of the at least one of atmospheric hydrogen sulfide and dissolved sulfide downstream of the nitrate source and the alkaline material source, for reducing an amount of nitrate that is added to the wastewater to reduce the level of the at least one of atmospheric hydrogen sulfide and dissolved sulfide  
5 downstream of the nitrate source and the alkaline material source to a desired level.

46. The wastewater treatment system of claim 45, wherein the means for reducing the amount of nitrate added to the wastewater includes a computer implemented controller operatively connected to the nitrate source, the alkaline material source, and the  
10 at least one sensor.

47. The wastewater treatment system of claim 45, wherein the means for reducing the amount of nitrate added to the wastewater includes means for adding an amount of alkaline material to the wastewater.

15 48. The wastewater treatment system of claim 45, wherein the means for reducing the amount of nitrate added to the wastewater includes:

at least one of a first valve or pump in fluid communication with the nitrate source and the wastewater;

20 at least one of a second valve or pump in fluid communication with the alkaline material source and the wastewater; and

a computer implemented controller, electrically coupled to the at least one of the first valve or pump, the at least one of the second valve or pump, and the at least one sensor.

25 49. The wastewater treatment system of claim 48, wherein the controller is programmed to add a sufficient amount of alkaline material to the wastewater to raise a pH of the wastewater downstream of the nitrate source and the alkaline material source by approximately one unit of pH.

30 50. The wastewater treatment system of claim 48, wherein the controller is programmed to add a sufficient amount of alkaline material to the wastewater to raise a pH

of the wastewater downstream of the nitrate source and the alkaline material source to between approximately 7.5 and 8.5 units of pH.

51. The waste water treatment system of claim 48, wherein the at least one  
5 sensor includes:

a first sensor, disposed downstream of the nitrate source and the alkaline material source, to measure the level of atmospheric hydrogen sulfide downstream of the nitrate source and the alkaline material source; and

10 a second sensor, disposed downstream of the nitrate source and the alkaline material source, to measure the level of dissolved sulfide downstream of the nitrate source and the alkaline material source.

52. The wastewater treatment system of claim 51, wherein the controller is  
programmed to adjust an amount of alkaline material added to the wastewater in response  
15 to the measured level of atmospheric hydrogen sulfide from the first sensor and the measured level of dissolved sulfide from the second sensor.

53. A computer readable medium encoded with a program that, when executed  
on a processor of a computer, performs a method of treating a wastewater stream,  
20 comprising acts of:

(a) adding a nitrate containing compound at a first position in the wastewater stream;

(b) adding an alkaline material at a second position in the wastewater stream;

(c) sensing a level of at least one of atmospheric hydrogen sulfide, dissolved  
25 sulfide, and residual nitrate in the wastewater stream downstream of the first and second positions; and

(d) adjusting an amount of at least one of the nitrate containing compound and the alkaline material added to the wastewater stream in response to the act of sensing.

30 54. The computer readable medium of claim 53, wherein the act (b) includes an act of adding the alkaline material in an amount sufficient to raise a pH of the wastewater stream downstream of the first and second positions by approximately one unit of pH.

55. The computer readable medium of claim 53, wherein the act (b) includes an act of adding the alkaline material in an amount sufficient to raise a pH of the wastewater stream downstream of the first and second positions to between approximately 7.5 and 8.5 units of pH.

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56. The computer readable medium of claim 53, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide and the level of dissolved sulfide in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of increasing an amount of the nitrate containing compound added in act (a) when the level of at least one of atmospheric hydrogen sulfide and dissolved sulfide sensed in act (c) is greater than a desired level.

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57. The computer readable medium of claim 53, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide and the level of dissolved sulfide in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of increasing an amount of the alkaline material added in act (b) when the level of at least one of atmospheric hydrogen sulfide and dissolved sulfide sensed in act (c) is greater than a desired level.

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58. The computer readable medium of claim 53, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide and the level of dissolved sulfide in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes acts of increasing an amount of the nitrate containing compound added in act (a) and increasing an amount of the alkaline material added in act (b) when the level of atmospheric hydrogen sulfide and the level of dissolved sulfide sensed in act (c) are greater than a desired level.

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59. The computer readable medium of claim 53, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide and the level of dissolved sulfide in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of decreasing an amount of the nitrate containing compound added in act (a) when the level of at least one of atmospheric hydrogen sulfide and dissolved sulfide sensed in act (c) is less than a desired level.

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60. The computer readable medium of claim 53, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide and the level of dissolved sulfide in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of decreasing an amount of the alkaline material added in act (b) when  
5 the level of at least one of atmospheric hydrogen sulfide and dissolved sulfide sensed in act (c) is less than a desired level.

61. The computer readable medium of claim 53, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide and the level of dissolved sulfide  
10 in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes acts of decreasing an amount of the nitrate containing compound added in act (a) and decreasing an amount of the alkaline material added in act (b) when the level of atmospheric hydrogen sulfide and the level of dissolved sulfide sensed in act (c) are less than a desired level.

15 62. The computer readable medium of claim 53, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide, the level of dissolved sulfide, and the level of residual nitrate in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of decreasing an amount of the nitrate  
20 containing compound added in act (a) when the level of atmospheric hydrogen sulfide and the level of dissolved sulfide sensed in act (c) are less than a desired level and an average level of residual nitrate sensed in act (c) is approximately 1-2 mg/L or greater.

63. The computer readable medium of claim 62, further comprising acts of:  
25 (e) sensing a pH of the wastewater stream at or prior to the second position; and  
(f) sensing a pH of the wastewater stream downstream of the first and second positions.

64. The computer readable medium of claim 63, wherein the act (d) further  
30 includes an act of decreasing an amount of the alkaline material added in act (b) when the act (f) indicates that the pH of the wastewater downstream of the first and second positions is at least one unit of pH higher than the pH of the wastewater stream sensed in act (e).

65. The computer readable medium of claim 53, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide, the level of dissolved sulfide, and the level of residual nitrate in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of decreasing an amount of the alkaline material added in act (b) when the level of atmospheric hydrogen sulfide sensed in act (c) is less than a first desired level, the level of dissolved sulfide sensed in act (c) is greater than a second desired level, and an average level of residual nitrate sensed in act (c) is approximately 1-2 mg/L or greater.

10 66. The computer readable medium of claim 53, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide, the level of dissolved sulfide, and the level of residual nitrate in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of increasing an amount of the alkaline material added in act (b) when the level of atmospheric hydrogen sulfide sensed in act (c) is greater than a first desired level, the level of dissolved sulfide sensed in act (c) is less than a second desired level, and an average level of residual nitrate sensed in act (c) is approximately 1-2 mg/L or greater.

67. The computer readable medium of claim 53, further comprising acts of:  
20 (e) sensing a pH of the wastewater stream at or prior to the second position; and  
(f) sensing a pH of the wastewater stream downstream of the first and second positions.

68. The computer readable medium of claim 67, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide and the level of dissolved sulfide in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of decreasing an amount of the alkaline material added in act (b) when the level of atmospheric hydrogen sulfide and the level of dissolved sulfide sensed in act (c) are less than a desired level, and the act (f) indicates that the pH of the wastewater downstream of the first and second positions is at least one unit of pH higher than the pH of the wastewater stream sensed in act (e).

69. The computer readable medium of claim 67, wherein the act (c) includes an act of sensing the level of atmospheric hydrogen sulfide, the level of dissolved sulfide, and the level of residual nitrate in the wastewater stream downstream of the first and second positions, and wherein the act (d) includes an act of decreasing an amount of the alkaline material added in act (b) when the level of atmospheric hydrogen sulfide and the level of dissolved sulfide sensed in act (c) are less than a desired level, the level of residual nitrate sensed in act (c) is negligible, and the act (f) indicates that the pH of the wastewater downstream of the first and second positions is at least one unit of pH higher than the pH of the wastewater stream sensed in act (e).